Construction of Common Coil Magnets

VLHC Magnet Workshop

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Magnet Program at LBNL

- Development of high field accelerator magnets utilizing brittle materials
  - New direction (within the last year)
- Build a series of coil modules and magnets utilizing this design
  - reaching 14 T in less than 2 years
- First step – Nb_3Sn magnet with a field of 6 T

Common Coil Concept

Current focus of R&D effort

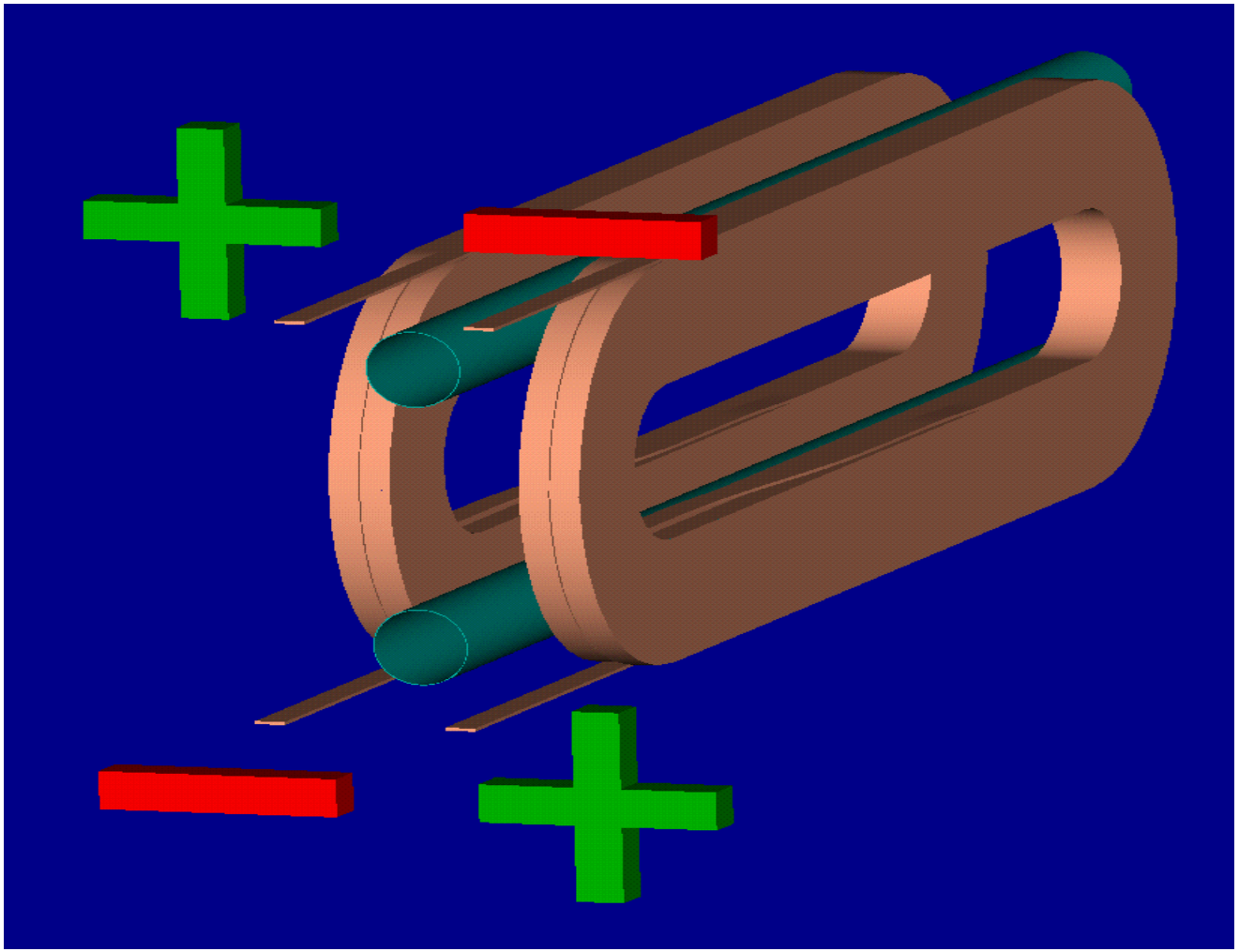
Racetrack Coils

- ***Simple*** geometry for utilization of brittle materials

Also

- Easy to fabricate – lower cost

Common Coil Configuration



Mechanical Coil Models

- Basic component is the Coil Module
  - Independent preload
  - Modular/interchangeable
  - Experiment with end support, preload, strain control
  - Bullet proof coil package
  - Put high risk fabrication steps up front

- Support Structure
  - Simple clamping structure allows for easy variation of the preload
  - Decouples vertical and horizontal prestress

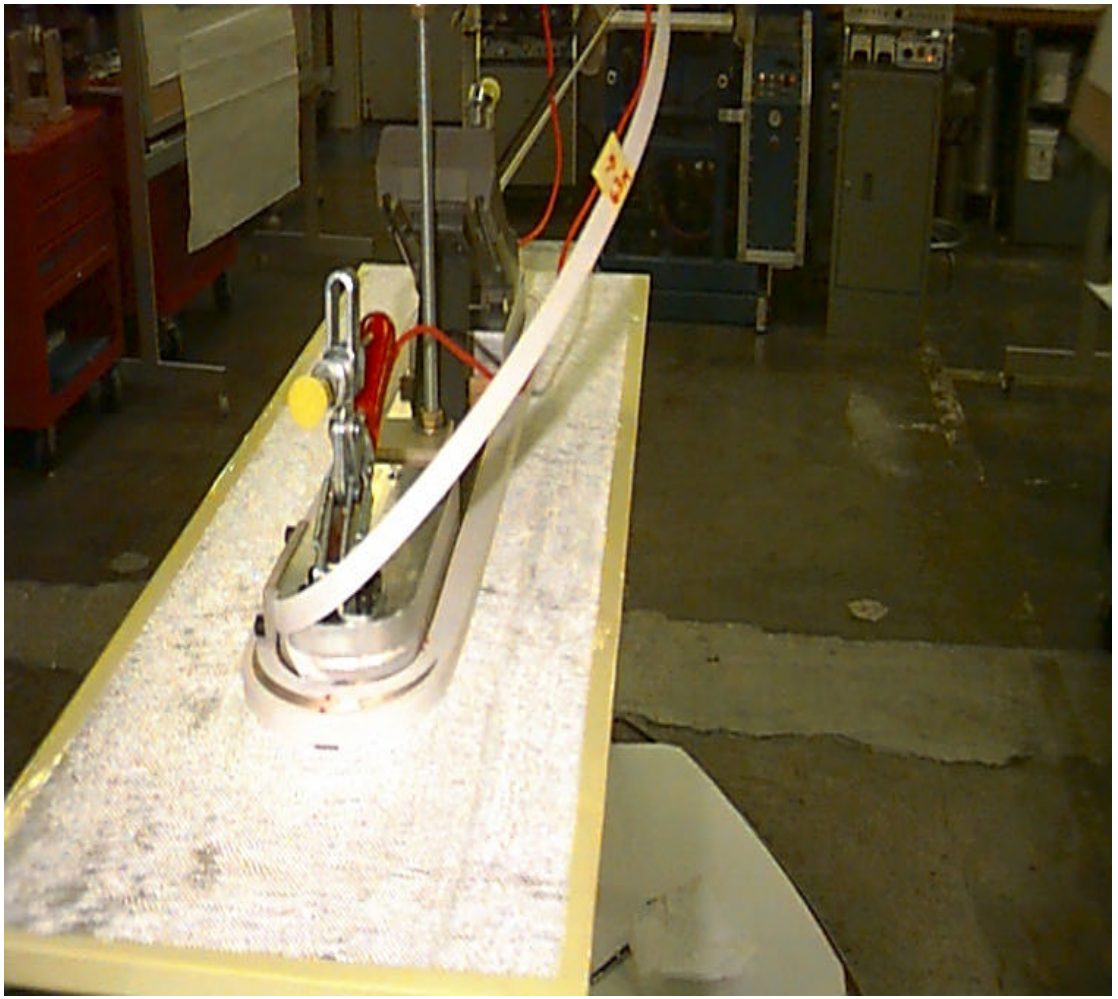
RD-2-01

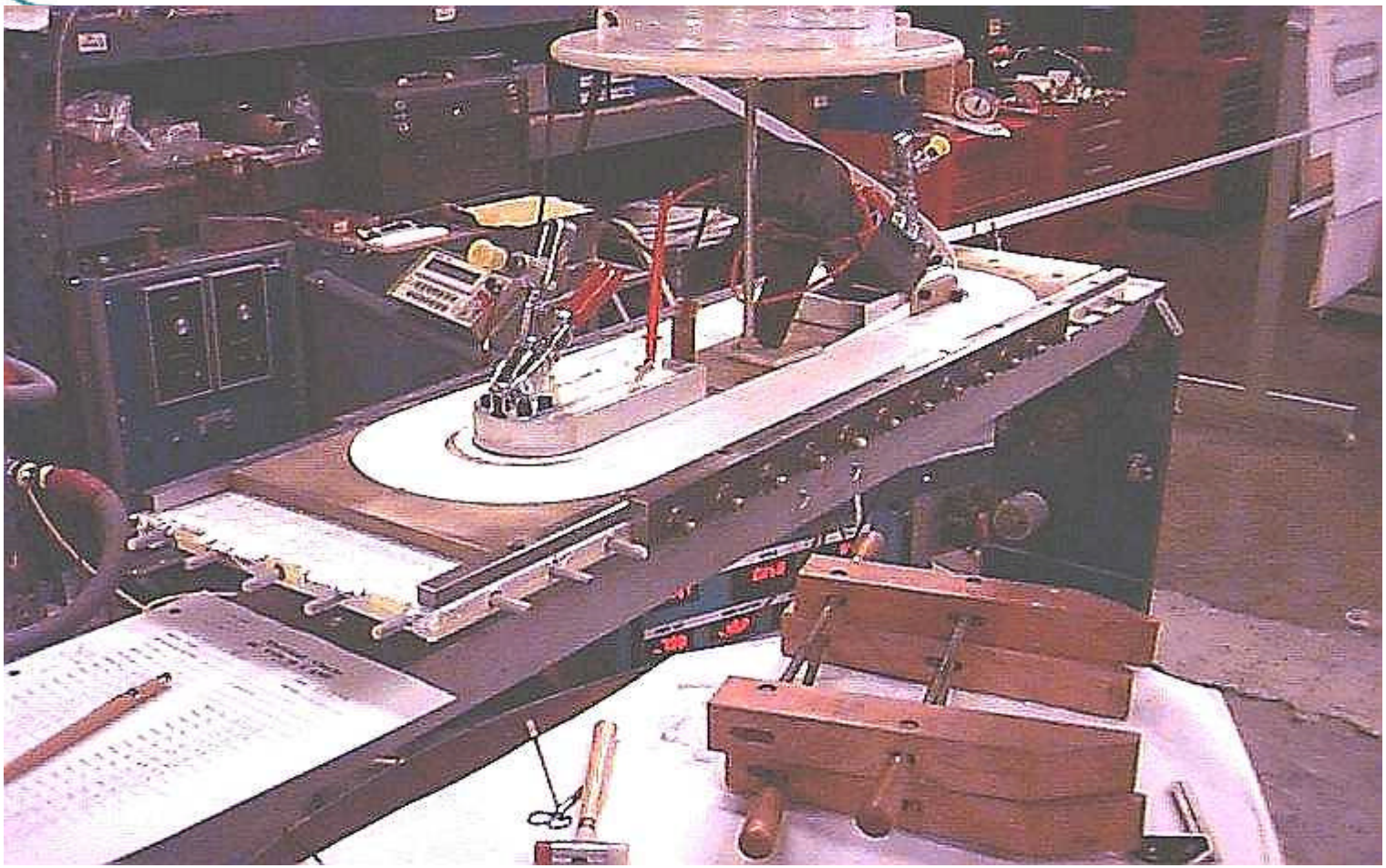
First Magnet in the series - Specifications

- 6 Tesla, 2-Layer Racetrack
- ITER Conductor
  - 650 A/mm2, 12T, 4.2K
- (New spec is asking for more than 3 times that Jc)
- Cable
  - 0.808 mm Nb_3Sn strand
- Rectangular SSC Inner Geometry
- Coil Spacing 30 mm +
- Coil Length 50 cm
- Coil Radius 40 mm
- Overall Length 1 m

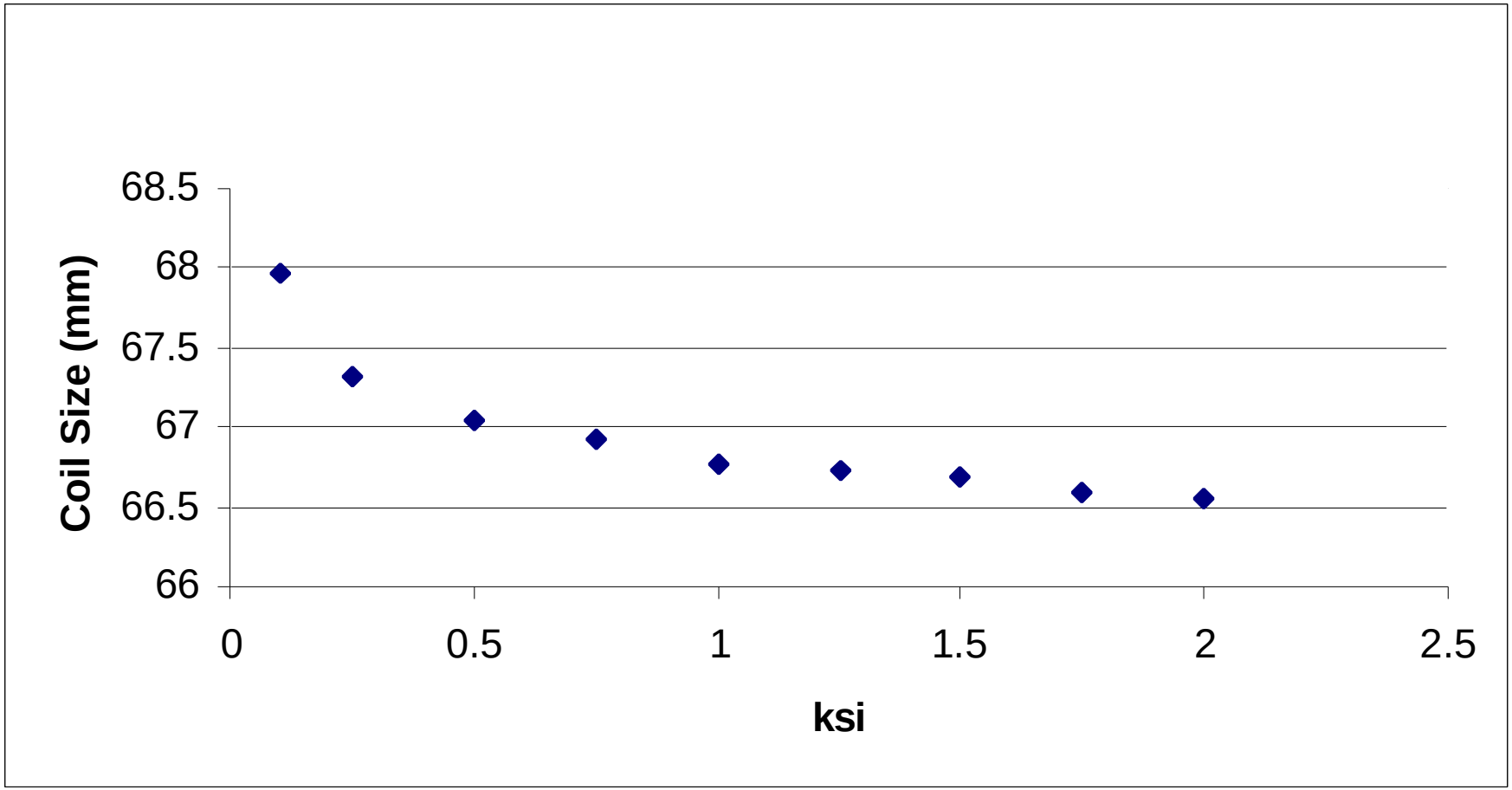
Fabrication steps

- Winding
  - Glass sleeve insulation (0.13 mm)
  - Mica paper on all metal parts
  - Field reducing end spacers
- Coil Sizing
  - Determines glass/epoxy fraction
- Reaction
  - Form Nb3Sn
  - Two—Three week cycle with maximum temperature of 650 – 680 ^{0}C
  - Two-part pole piece for thermal expansion control

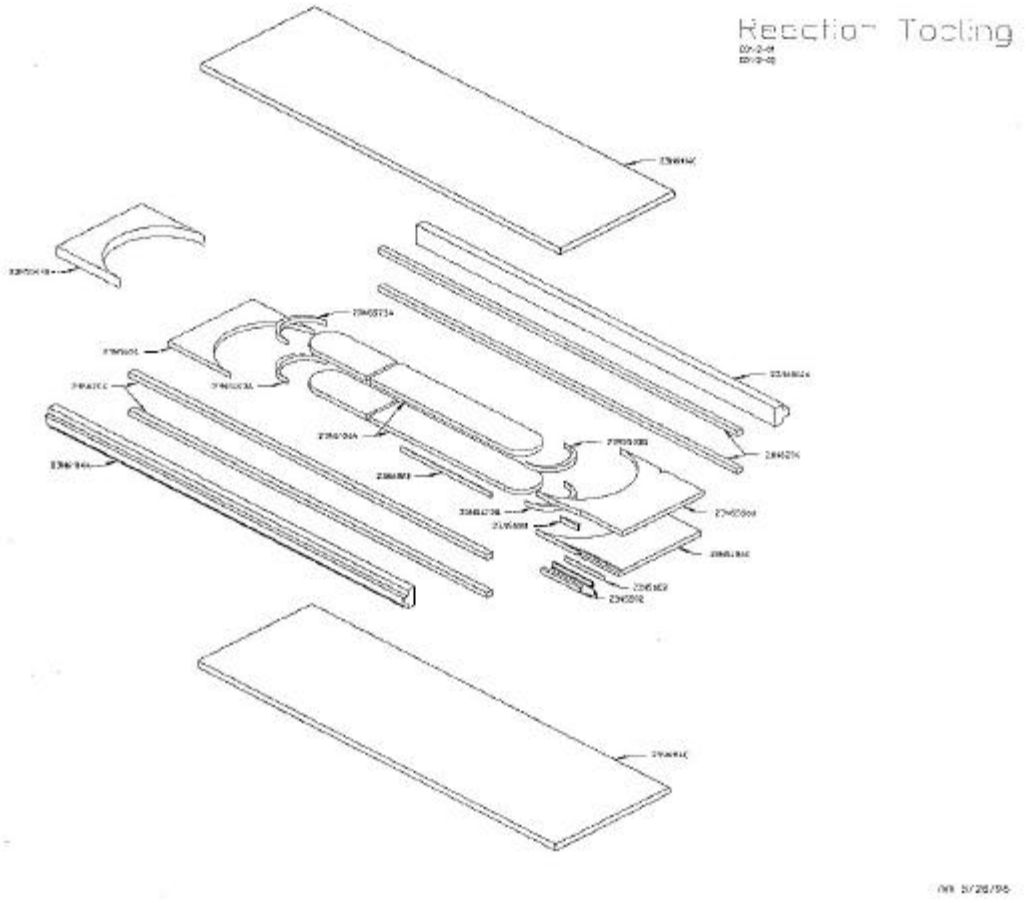


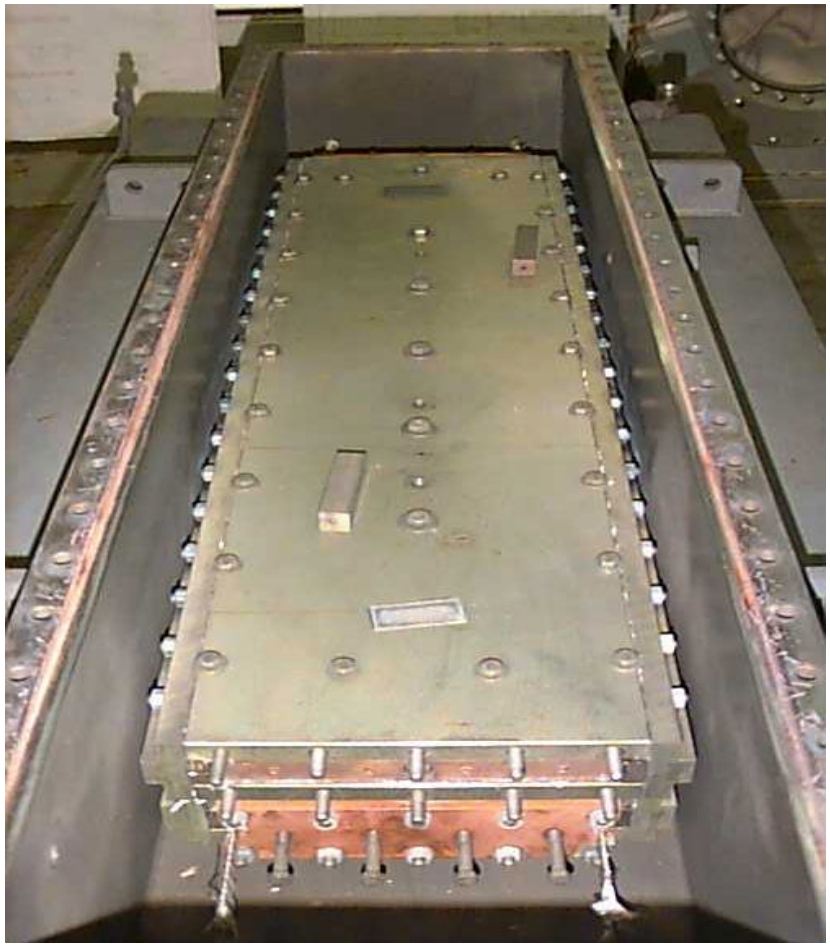


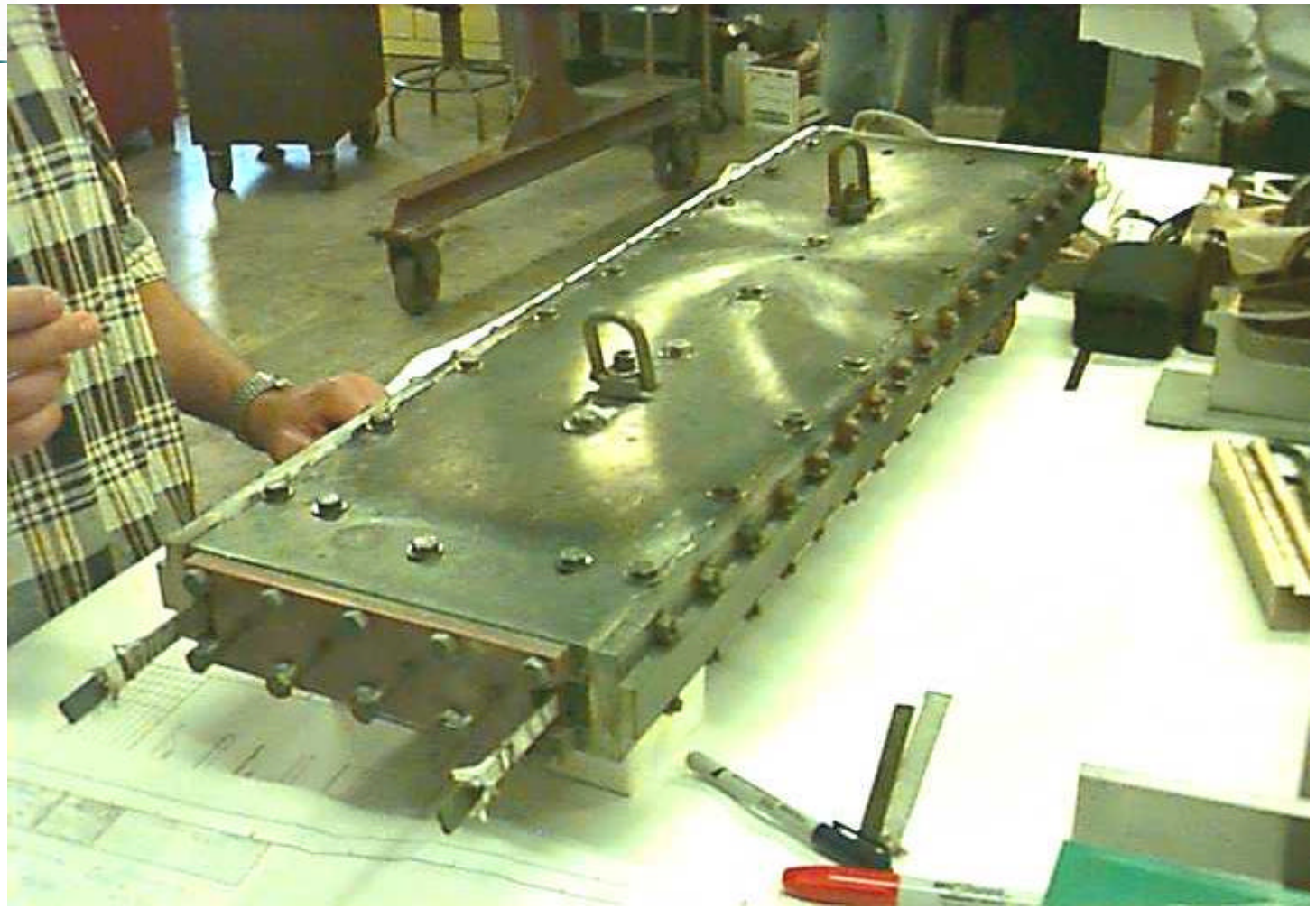
Coil Size Under Load



Coil Parts and Reaction Tooling



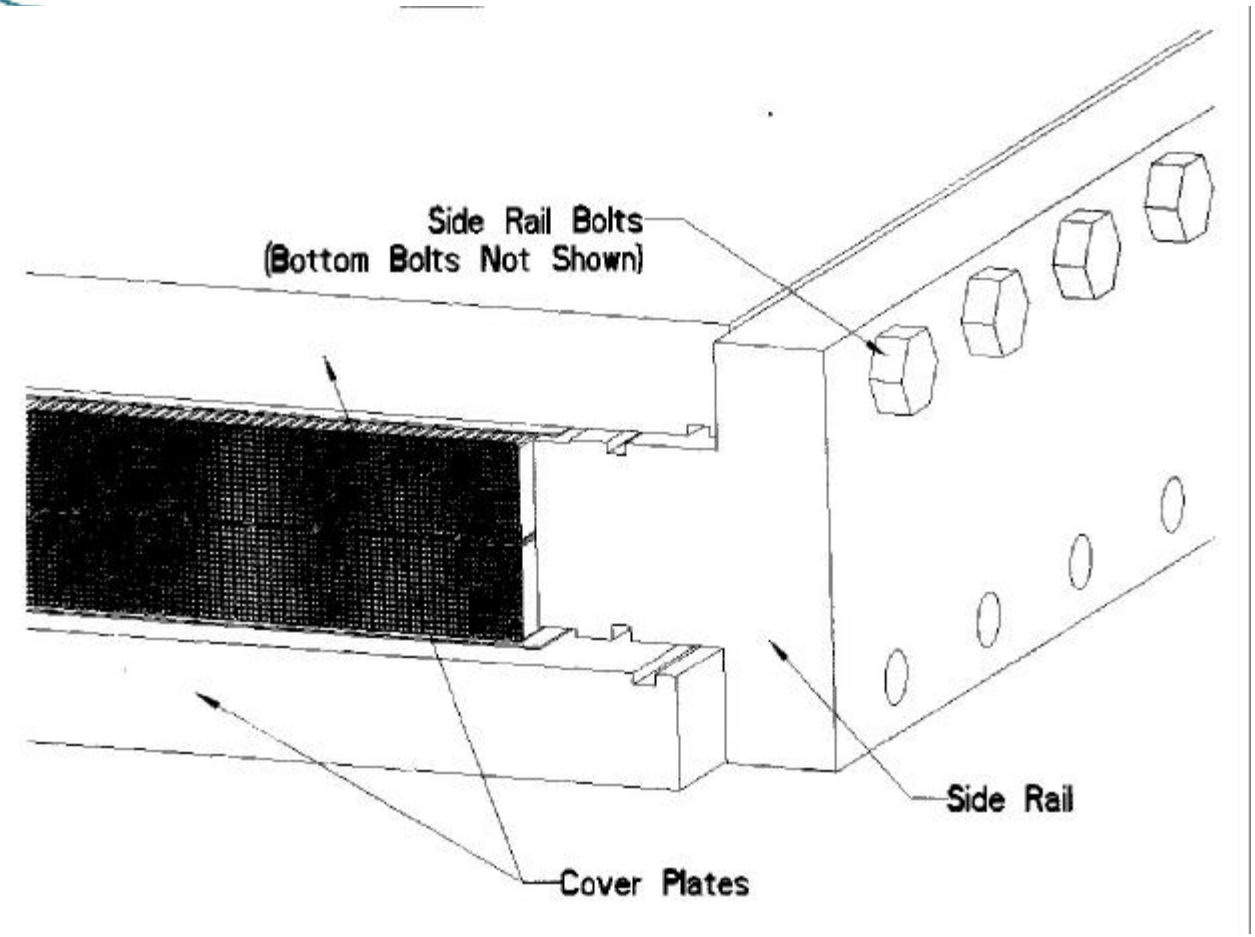


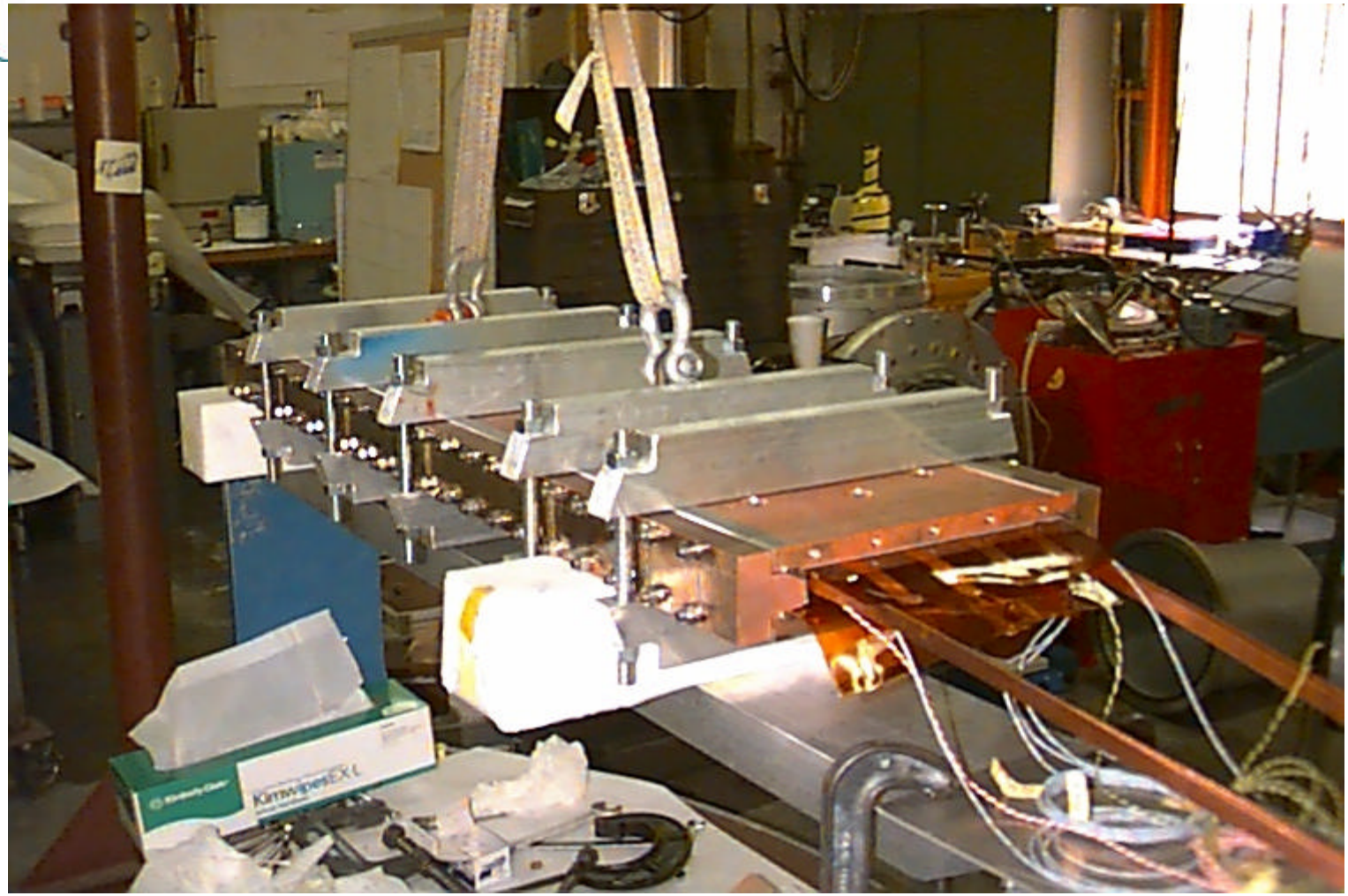


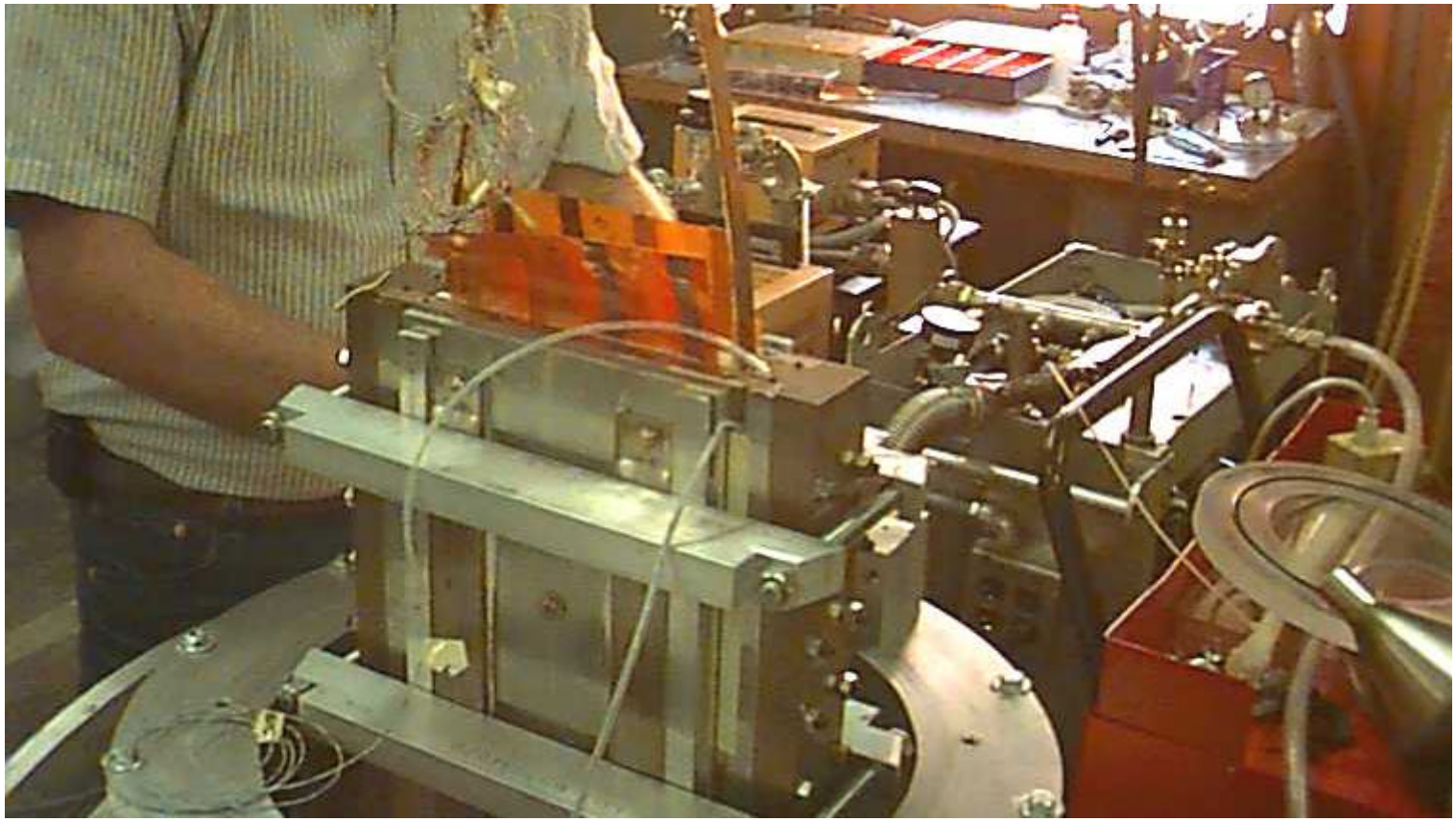
Fabrication steps (cont'd)

- Epoxy Impregnation
  - Make NbTi/Nb_3Sn splices
  - Install laminated Kapton, Stainless/copper sheet containing VT readout, heaters
  - Add gauges
  - Vacuum impregnate with CTD-101
    - Low viscosity, good mechanical properties at low temp
    - Achieve good surface matching between coil and support structure (no gaps)

Also implies low part tolerances

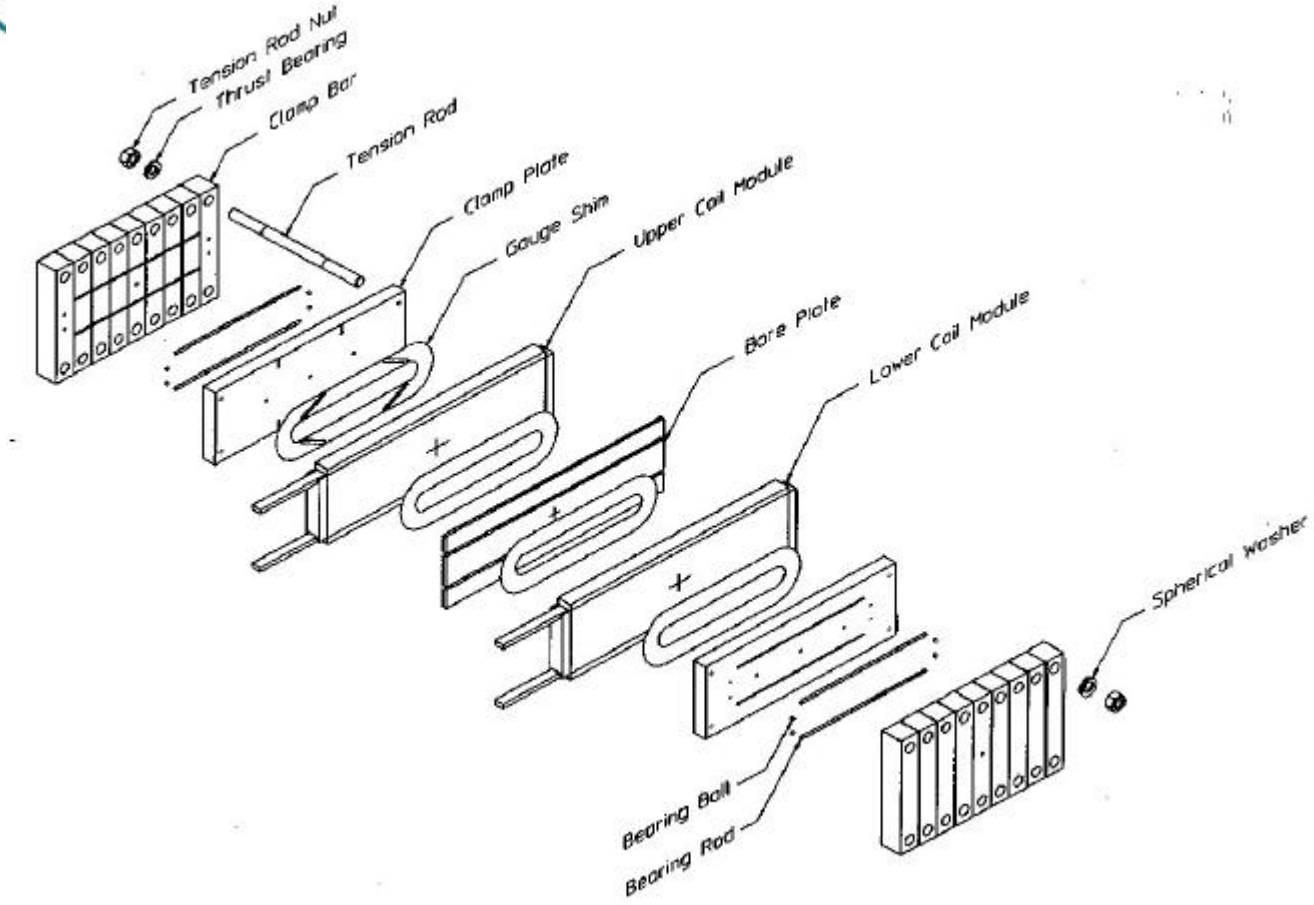

Side Rail Bolts
(Bottom Bolts Not Shown)
Side Rail
Cover Plates

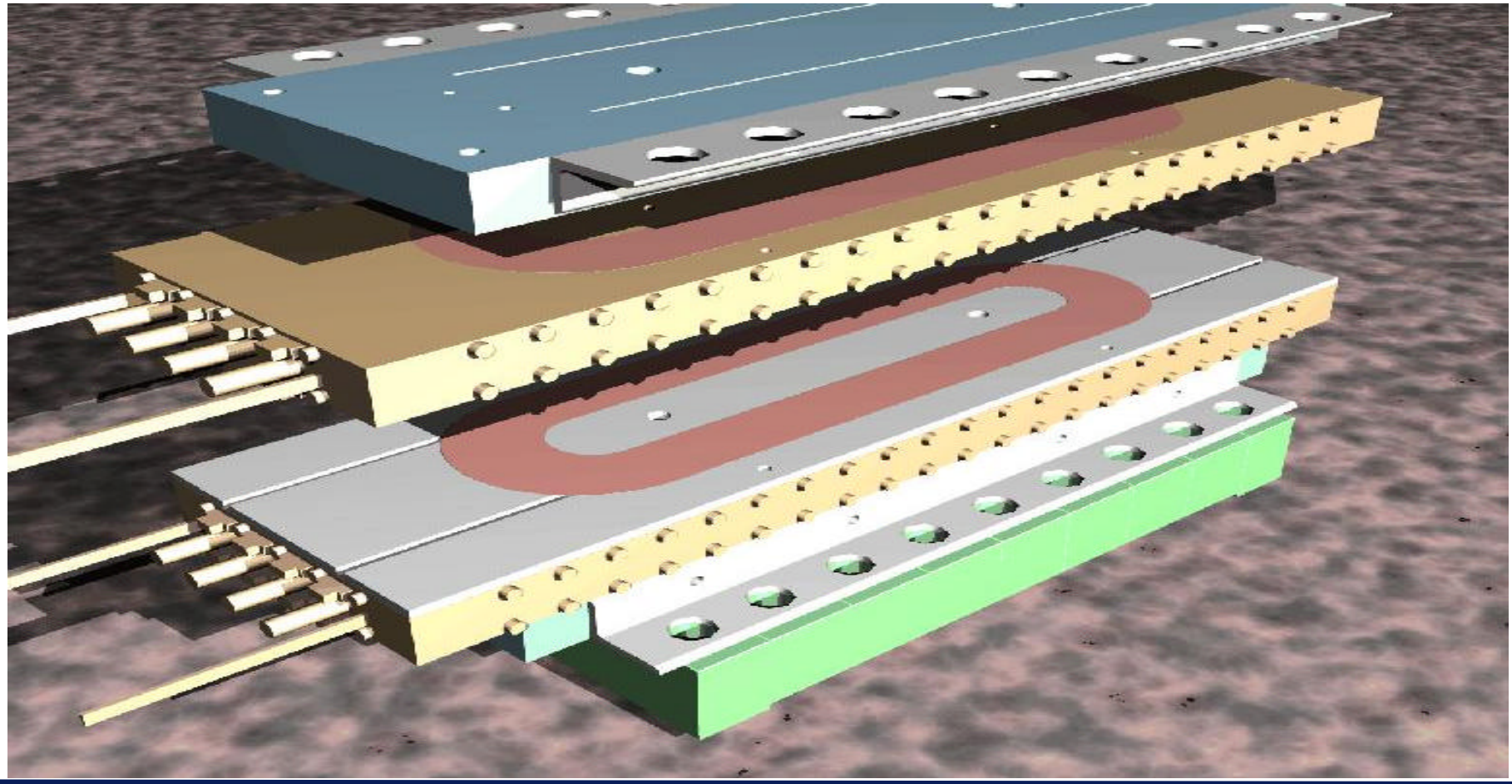


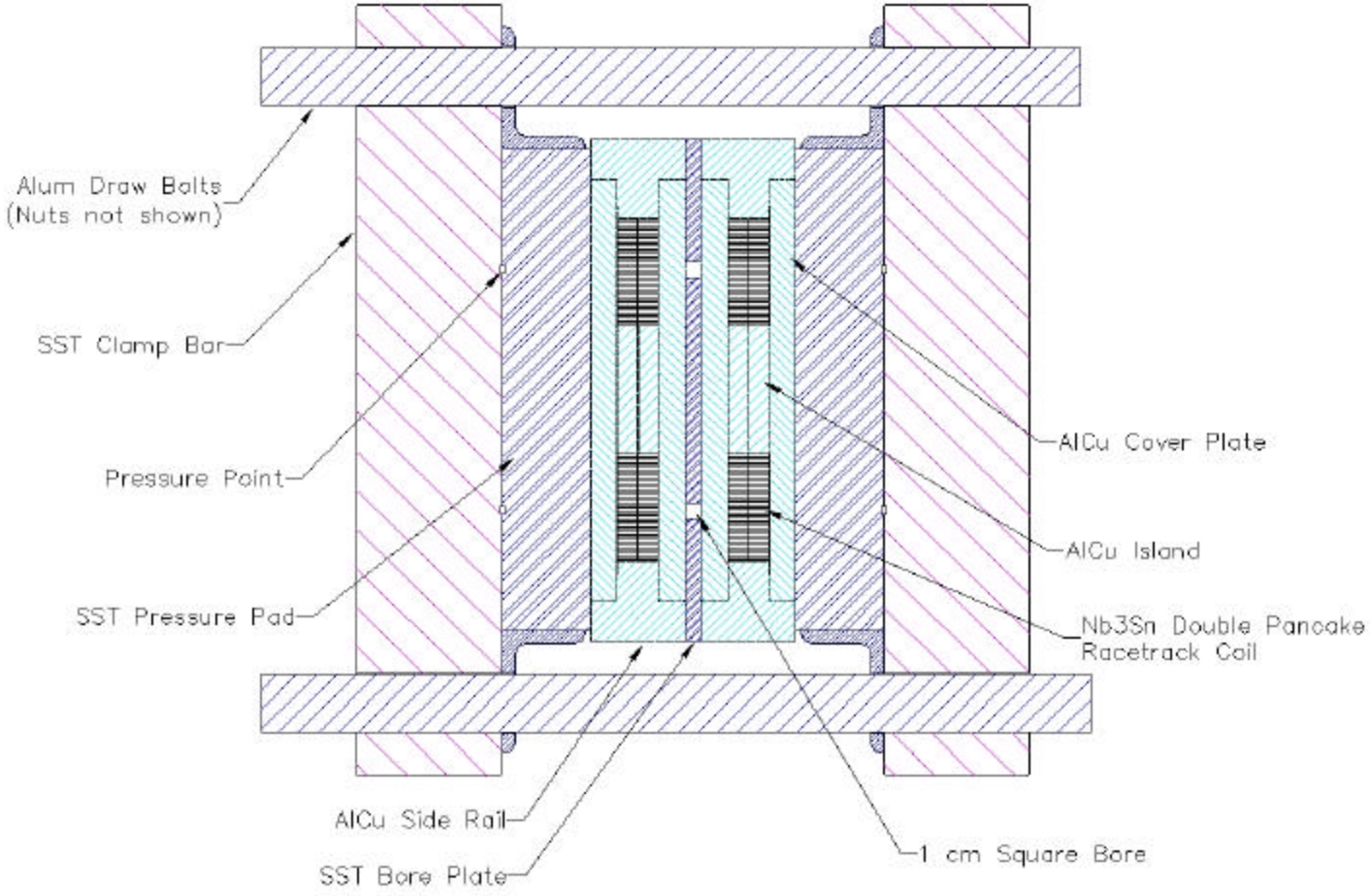


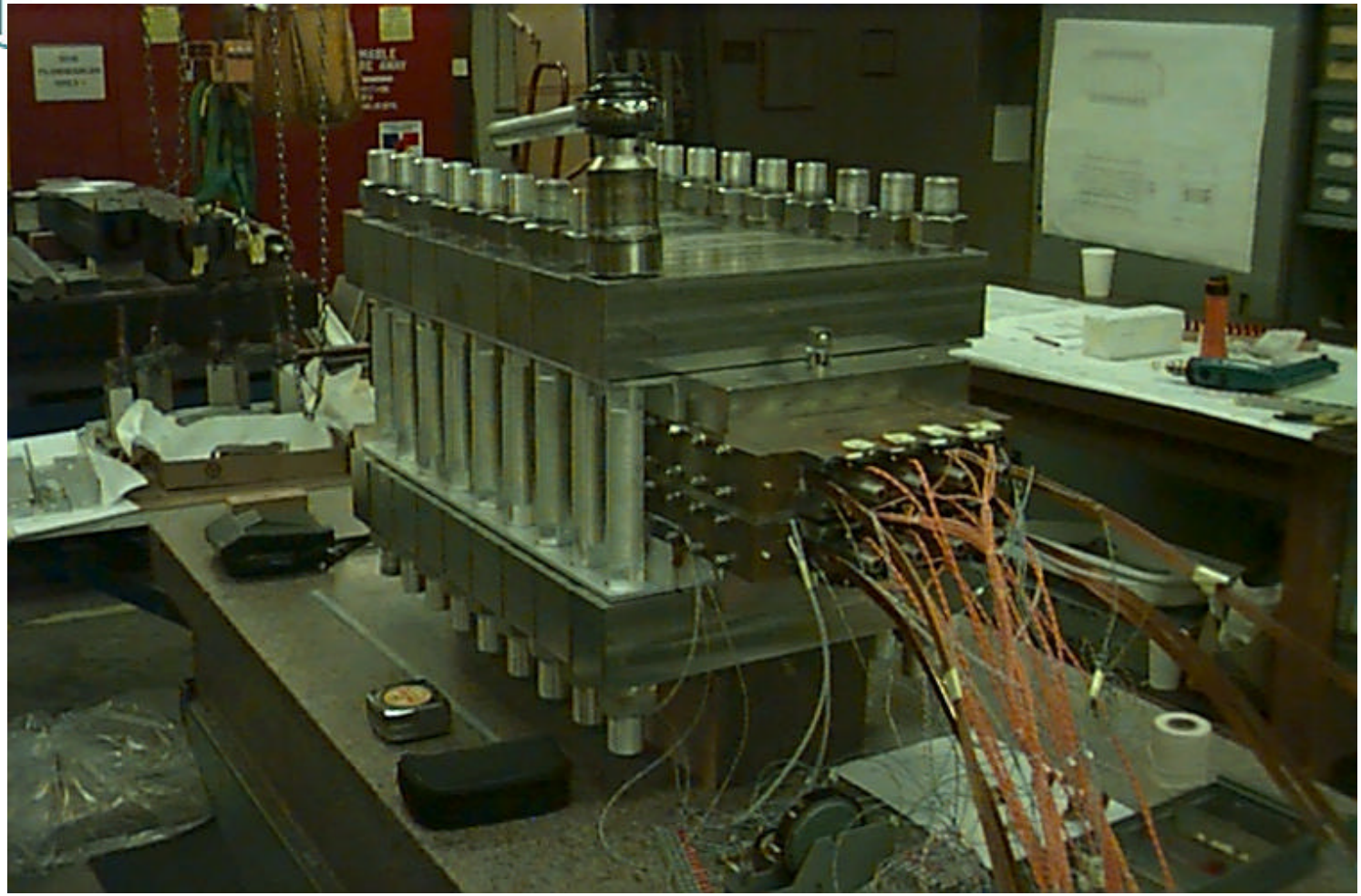
Fabrication steps (cont'd)

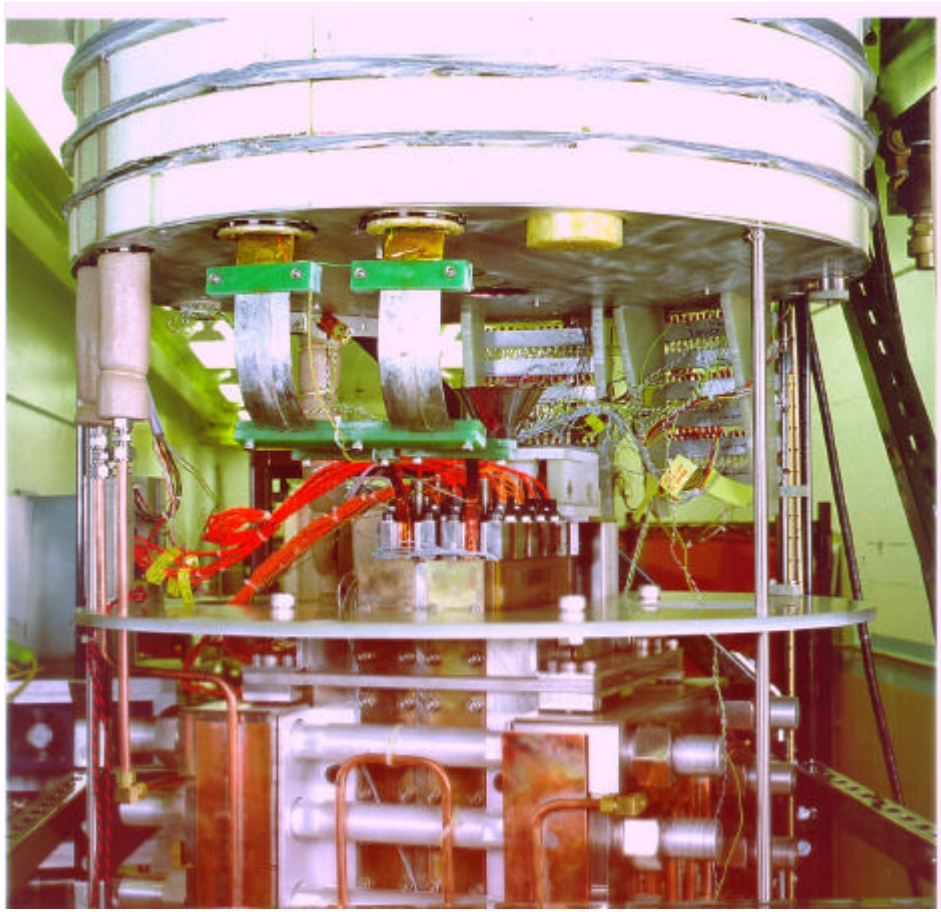
- Apply vertical preload
- In R&D model, preload is easily adjustable via a shim between cover plate and side rails
- Insert into support structure (Horizontal preload)
- Low field models use simple bolted structure for interchangeability
- Adjustable for studies


Tension Rod Nut
Thrust Bearing
Clamp Bar
Tension Rod
Clamp Plate
Gauge Shim
Upper Coil Module
Bore Plate
Lower Coil Module
Spherical Washer
Bearing Ball
Bearing Rod




Alum Draw Bolts
(Nuts not shown)
SST Clamp Bar
Pressure Point
SST Pressure Pad
AlCu Side Rail
SST Bore Plate
AlCu Cover Plate
AlCu Island
Nb3Sn Double Pancake
Racetrack Coil
1 cm Square Bore





Mechanical Variations of RD-2

- RD-2-01 Full horizontal and vertical preload
- RD-2-02 Minimal horizontal preload
- RD-2-03 Reduced vertical preload

  – to be tested next month

Primary Issues for Nb_3Sn Magnets

Conductor Development

- Cost
  - By far the most important
  - Efforts are being organized to attack the problem
- Strain sensitivity?
  - ***May not*** be a problem even up to 16 T
  - But we're studying it…
- Cable degradation
  - What happened to ITER cable for RD-2?

Issues (cont'd)

Fabrication

- Experience so far….
  - Simple to build

- Relatively few parts, simple geometry, low tolerances

As we progress…

Preserve simplicity of Common Coil Design in an accelerator magnet with good field quality

Issues (cont'd)

Need to work more on . . .

- Insulation
  - Reduce organic component (insulation sizing)
  - Thinner, more robust
  - Increase modulus
- Instrumentation
- Investigate react and wind
- Look ahead to long magnets
  - (manufacturability)

Current Status

- On 3rd mechanical iteration of first magnet
- 14 T Magnet by next Fall (3-layers, best available conductor)
- Field quality design to closely follow

14 Tesla Design